

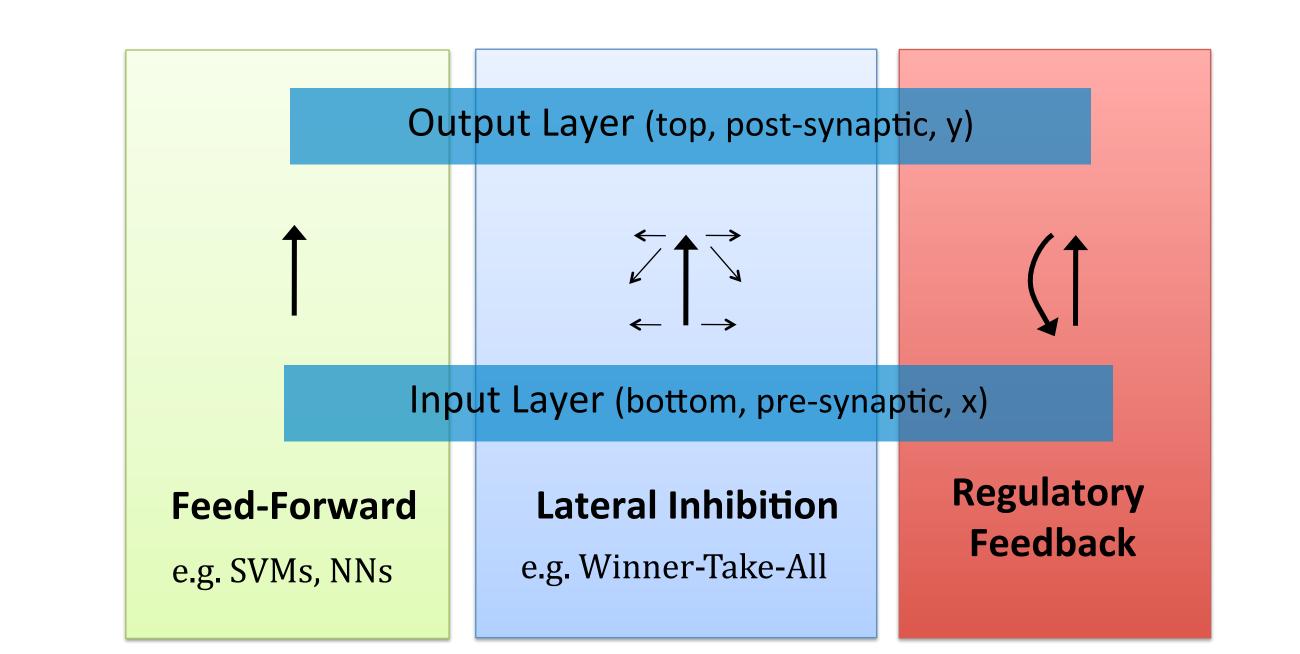
Towards Understanding the Role of Regulatory Feedback in Simultaneous Pattern Processing

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Synopsis:

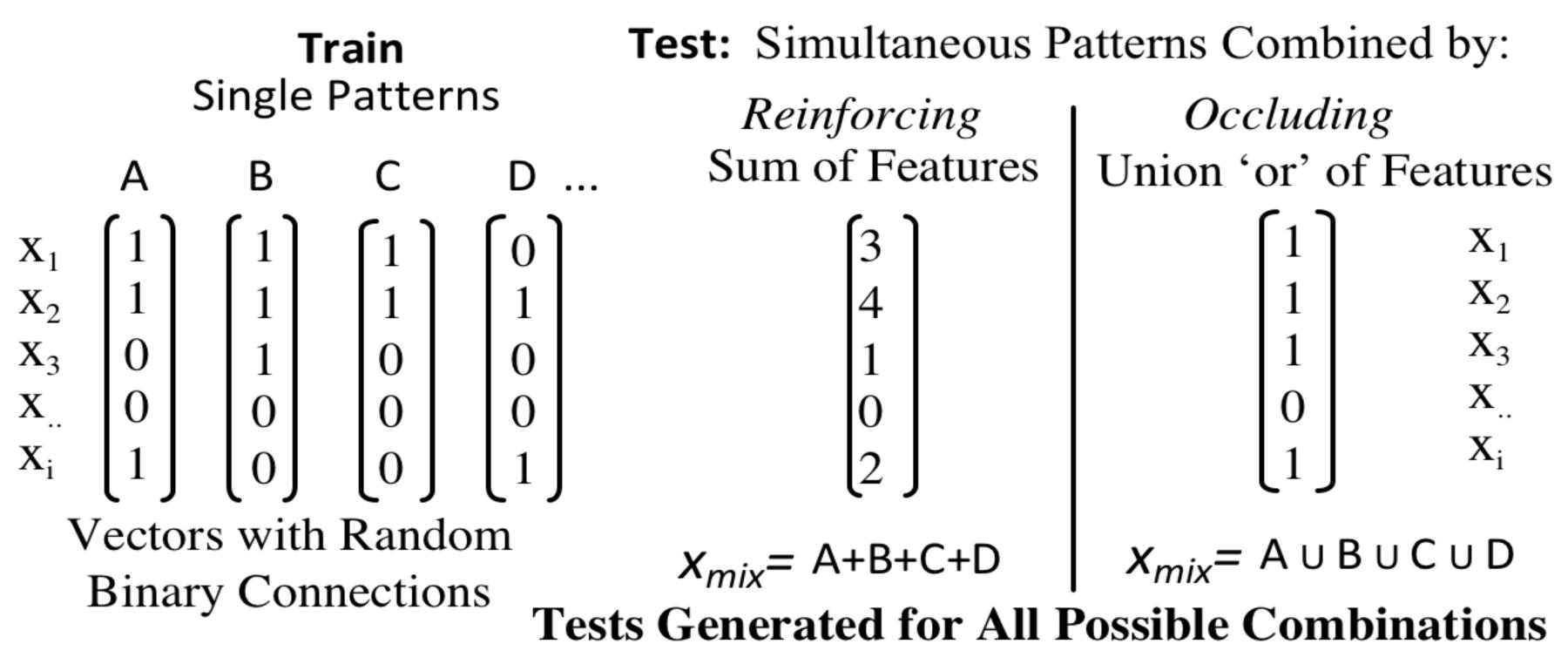
What is the role of large numbers of top-down output-to-input reentrant connections in sensory processing regions? Simulations show reentrant regulatory feedback connections can promote simultaneous pattern processing:



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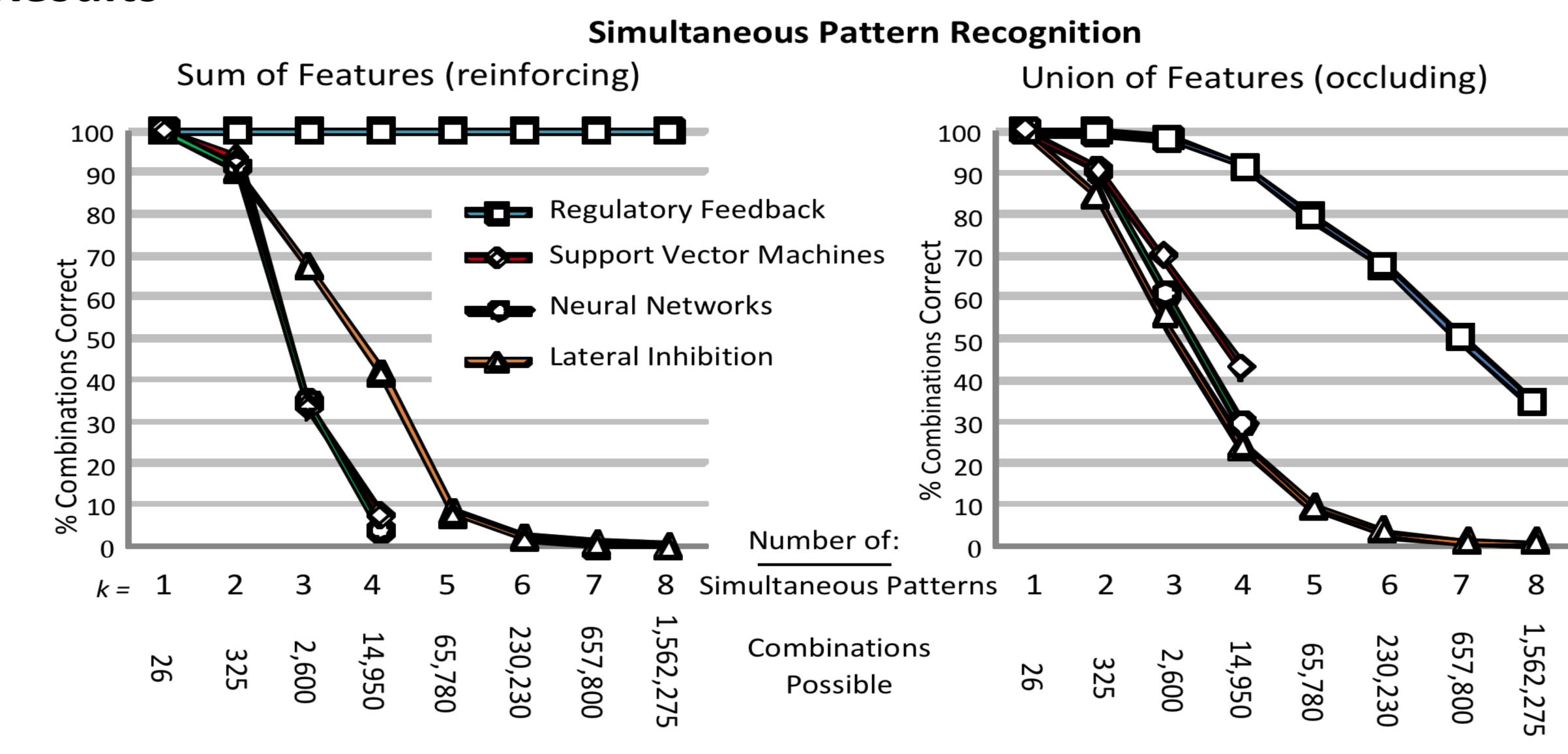
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Test Method



Training with 26 single, randomly generated patterns and testing with simultaneous patterns. Test patterns are combinations of the trained patterns (either addition or union). Only 5 features are shown. At the end of each test, the top k output (y-values) are selected and their identity is compared to the patterns in \mathbf{x}_{mix} . If the top k nodes match the patterns that were used to compose the \mathbf{x}_{mix} , then a correct classification for that combination/test is recorded. This is plotted as the percent correct of the possible tests. For example suppose k=3 (2,600 tests are performed), SVM recognized all 3 patterns in 1,560 of those tests then 60% is plotted for k=3.

Results

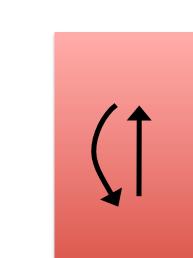


patterns are combined via addition or union, regulatory feedback is able to better recognize simultaneous pattern combinations. Single learned patterns (k=1) and pattern mixes of up to 8 simultaneously (k=2 .. 8) are presented to the networks that were trained on single patterns. Left: simultaneous patterns are composed by adding overlapping features. Only feedback regulation can inherently recognize all simultaneous patterns. Right: simultaneous patterns are composed by a union of overlapping features. Even though information can be lost in the union, regulatory feedback still outperforms other methods. SVM and NN performance is unavailable for k>4 because WEKA does not support such large numbers of test sets.

About Regulatory Feedback

Governing Equations

The activity of each output node is determined by:



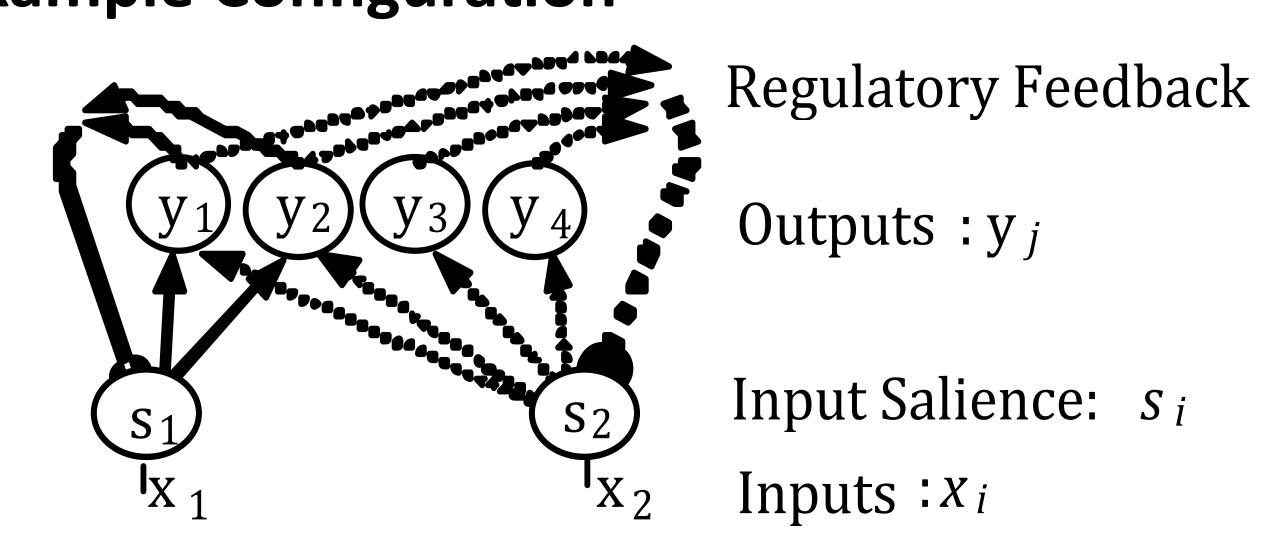
$$y_{j}(t+dt) = \frac{y_{j}(t)}{|FF_{j}|} \sum_{v \in FF_{j}} s_{v} \cdot d$$

The salience value s_i of a given x_i is determined by:

$$S_i = \frac{\sum_{r \in FB_i}^{X_i} y_r(t)}{\sum_{r \in FB_i}^{X_i} y_r(t)}$$

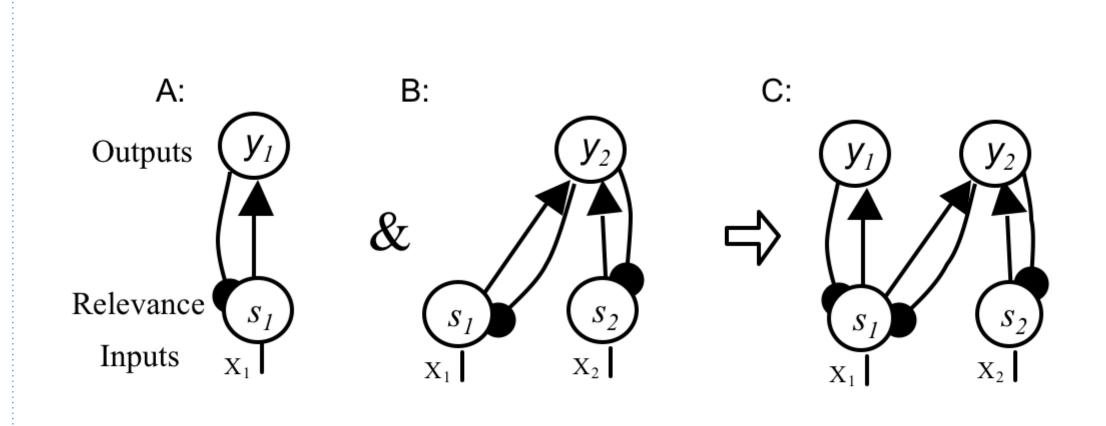
Each output node y_j receives feed-forward binary input connections FF_j . Symmetrical feedback connections FB_j project back to inputs and regulate them by modulating salience.

Example Configuration

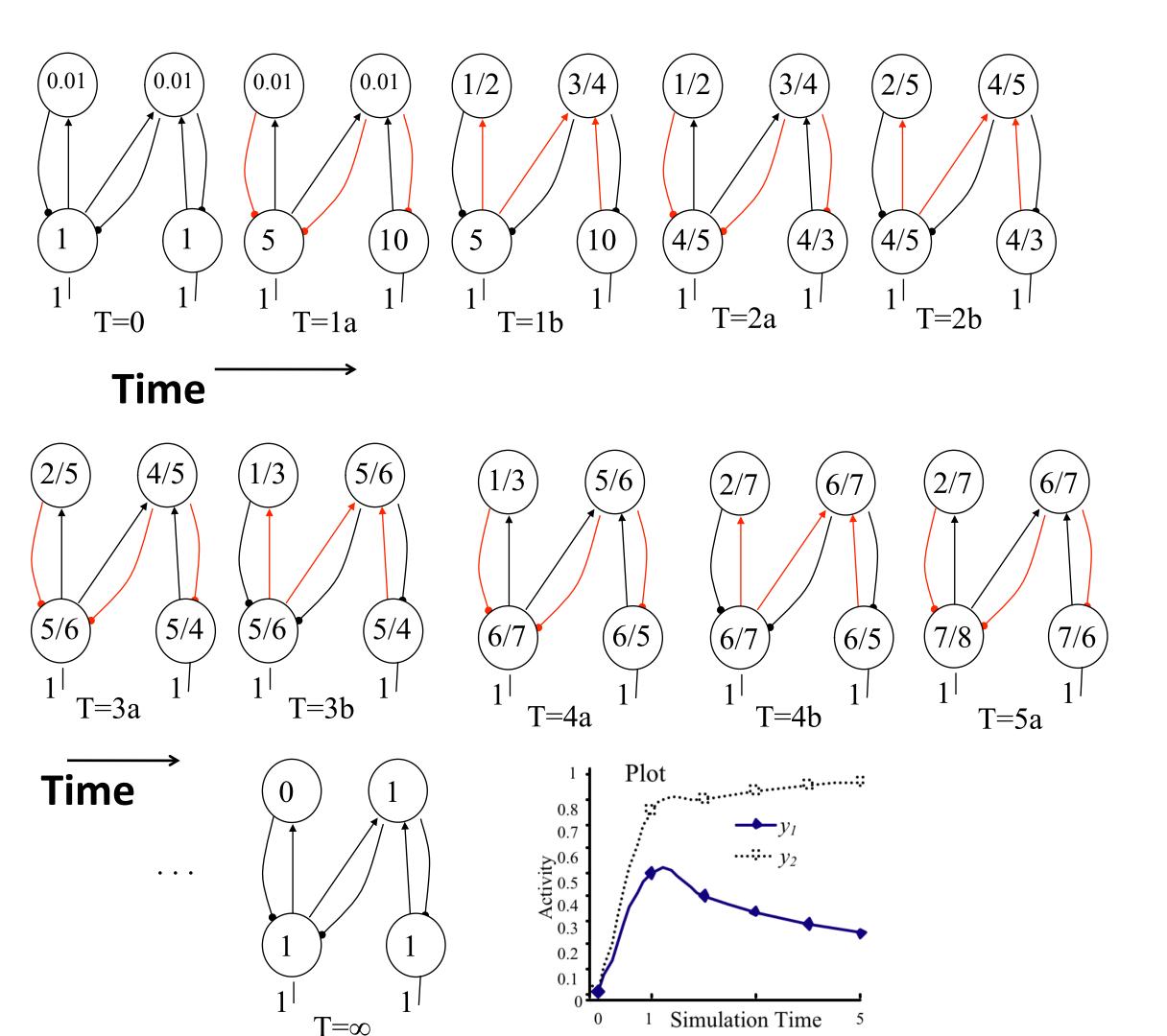


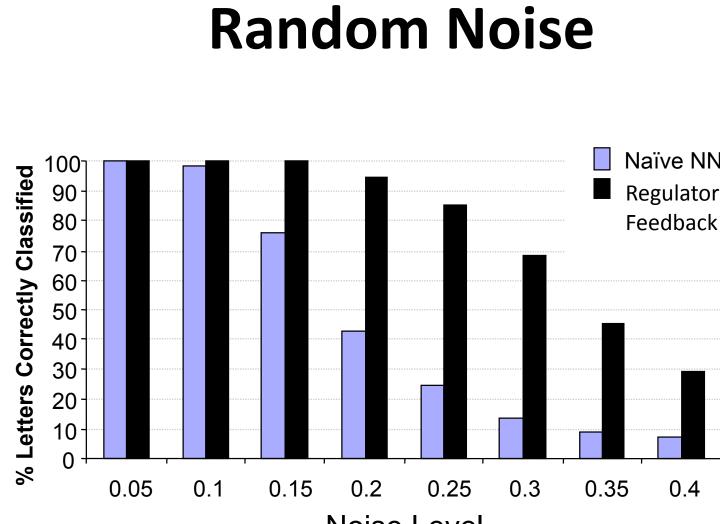
Schematic of symmetric self-regulation: if x_1 activates y_1 & y_2 then feedback from y_1 & y_2 regulates x_1 . Similarly if x_2 activates y_1 , y_2 , y_3 & y_4 then feedback from y_1 , y_2 , y_3 & y_4 regulates x_2 . For this example: $FB_1 = \{y_1, y_2\}$, $FB_2 = \{y_1, y_2, y_3, y_4\}$, $FF_1 = FF_2 = \{x_1, x_2\}$, $FF_3 = FF_4 = \{x_2\}$.

Simplest Example:



Demonstration of Simplest Network: Nodes y_1 and y_2 (A & B respectively) can be simply combined to form a network (C). No additions to the base nodes or new connections are needed. The nodes interact with each other at the common input, x_1 .





Resistance to

Conclusions:

- 1) Regulatory feedback adjusts input salience based on output use
- 2) After training with single patterns it can de-mix arbitrary combinations of those single patterns.

This suggests a neural method to compute salience and reason for ubiquitous feedback connections in sensory processing regions

even with virtually no spatial processing such as olfaction

Poforoncos

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- 2. Achler, T., C. Omar, and E. Amir, Shedding Weights: More With Less. Proceedings of the 2008 IEEE International Joint Conference on Neural Networks (IJCNN'08), 2008.
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